NATURAL CLIMATE SOLUTIONS

A Piece of the Puzzle
The Paris Agreement calls for an early peak in emissions, then a decline to net-zero emissions during the second half of the century.
Natural Climate Solutions

- Reducing deforestation
- Reducing forest degradation
- Improving forest management
- Reforestation
- Afforestation/Plantations
- Increasing soil C in croplands and grazing lands
- Biochar
- Improving nutrient management in croplands
- Restoring crop lands to prairie or savanna
- Restoring coastal ecosystems
- Protecting coastal peatlands
Big potential: $0.9 \times 10^9$ Ha and 205 Gt C (752 Gt CO$_2$)
How big?
Climate mitigation potential of 20 natural pathways

Climate mitigation potential in 2030 (PgCO₂e yr⁻¹)

- Forests:
  - Reforestation
  - Avoided Forest Conv.
  - Natural Forest Mgmt.
  - Improved Plantations
  - Avoided Woodfuel
  - Fire Mgmt.

- Ag. & Grasslands:
  - Biochar
  - Trees in Croplands
  - Nutrient Mgmt.
  - Grazing - Feed
  - Conservation Ag.
  - Improved Rice
  - Grazing - Animal Mgmt.
  - Grazing - Optimal Int.
  - Grazing - Legumes
  - Avoided Grassland Conv.

- Wetlands:
  - Coastal Restoration
  - Peat Restoration
  - Avoided Peat Impacts
  - Avoided Coastal Impacts

- Other benefits:
  - air
  - biodiversity
  - water
  - soil

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Natural climate solutions are not enough

Natural climate solutions, like forest management, do not lessen the need for mitigation from energy and industrial sectors.

Fate of anthropogenic CO$_2$ emissions (2008–2017)

<table>
<thead>
<tr>
<th>Sources</th>
<th>Sinks</th>
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</thead>
<tbody>
<tr>
<td>34.4 GtCO$_2$/yr</td>
<td>17.3 GtCO$_2$/yr</td>
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<tr>
<td>87%</td>
<td>44%</td>
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<tr>
<td>13%</td>
<td>29%</td>
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<tr>
<td>5.3 GtCO$_2$/yr</td>
<td>11.6 GtCO$_2$/yr</td>
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<td>22%</td>
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<td>8.9 GtCO$_2$/yr</td>
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<td>Budget Imbalance:</td>
<td>5%</td>
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<td>(the difference</td>
<td>1.9 GtCO$_2$/yr</td>
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<td>between estimated</td>
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<td>sources &amp; sinks)</td>
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Source: CDIAC; NOAA-ESRL; Houghton and Nassikas 2017; Hansis et al 2015; Le Quéré et al 2018; Global Carbon Budget 2018
Global carbon budget

Carbon emissions are partitioned among the atmosphere and carbon sinks on land and in the ocean. The “imbalance” between total emissions and total sinks reflects the gap in our understanding.

Balance of sources and sinks

Source: CDIAC; NOAA-ESRL; Houghton and Nassikas 2017; Hansis et al 2015; Joos et al 2013; Khatiwala et al. 2013; DeVries 2014; Le Quéré et al 2018; Global Carbon Budget 2018
Land-use change emissions are highly uncertain, with no clear trend in the last decade.

Estimates from two bookkeeping models, using fire-based variability from 1997
Source: Houghton and Nassikas 2017; Hansis et al 2015; van der Werf et al. 2017; Le Quéré et al 2018; Global Carbon Budget 2018
Total C in frozen soils: 4900 – 5800 Gt CO₂

Modeled C loss with high emissions: 340 Gt CO₂ by 2100 up to 1400 Gt CO₂ by 2300


Permafrost “bomb”

USGS
California forest carbon offsets: A real-world test
California forest carbon offsets: A real-world test

Anderson, Field, Mach. Frontiers in Ecology and Evolution 2018
California forest carbon offsets: A real-world test

Anderson, Field, Mach. Frontiers in Ecology and Evolution 2018
<table>
<thead>
<tr>
<th>Negative Emissions Technology</th>
<th>Estimated Cost ($/t CO₂)</th>
<th>Safe Potential Rate of CO₂ Removal Possible Given Current Technology and Understanding and at ≤$100/t CO₂ (Gt/yr CO₂)</th>
<th>Primary Current Limiting Factors</th>
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<tbody>
<tr>
<td></td>
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<td>US</td>
<td>Global</td>
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<tr>
<td>Coastal blue carbon</td>
<td>L</td>
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<td>Terrestrial carbon removal and sequestration: afforestation/ reforestation</td>
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Global Total, All Methods = 5-6 Gt CO₂/yr
Natural Climate Solutions

- Leakage
- Permanence
- Additionality

- Finance
- Governance
- Institutions